

Lightweight and Modern Metals Manufacturing Innovation (LM3I) Institute

Need: Advancing a systems-level approach to the design and manufacturing of lightweight components and structures is of great importance to the Department of Defense (DoD), Department of Energy (DoE), and other government agencies, because of their role in achieving enhanced system performance, greater energy efficiency, and lower life-cycle cost. It is also a priority of the Administration's Materials Genome Initiative, which the President announced on June 24, 2011. The government has made significant investments to reduce the cost of lightweight metals, intended for demanding critical applications. The cost of necessary scale-up and certification requirements, however, hinder the implementation of those materials. These critical applications have stringent requirements for reliability, which in turn place demands on the ability to control carefully the production of the materials to enable optimized, predictable material performance. Consequently, the design of new alloy systems requires years of expensive investments. These strict reliability requirements coupled with a hyper-competitive global marketplace for metals drove U.S. industry to choose production efficiency over expansion into new applications and markets. Until recently, this has resulted in a significant reduction in new alloy development and applications, particularly in lightweight metals. Notwithstanding recent advancements, new structural alloys continue to face tremendous barriers to application driven largely by a lack of design guides and certifications as well as cost and scale-up challenges. To accelerate time to market and fully leverage these new lightweight and novel metals, an *integrated approach* is required which includes systems engineering coupled with design of materials and advanced manufacturing.

National Economic Impact: The availability of advanced lightweight metals is a pervasive factor in improving the performance of many systems in defense, energy, transportation and general engineered products, each representing large sectors of the U.S. economy. Moreover, lightweight metals have additional applications in areas such as wind turbines, medical technology, pressure vessels and alternative energy sources. For example, new fuel economy standards put into place for cars and trucks will raise average fuel economy to 35.5 miles per gallon by 2016 and save 1.8 billion barrels of oil over the lifetime of the vehicles covered. Further, CAFE standards raise this to 54.5 mpg by 2025. These fuel efficiency requirements will no doubt continue to drive the need for increasingly lighter materials. The President's goal of having 1 million electric vehicles on the road by 2015 and becoming the world's leader in advanced vehicle technologies will also drive demand.

DOD Investment Rationale: DOD has an increasing need for affordable, lightweight metals across its unique systems and platforms. Lightweight metals have the potential for wide-ranging impact on the operational capabilities and technological superiority of U.S. defense systems. DoD needs to catalyze the investment in order to achieve an earlier maturation of the technology. This Institute will help to develop an advanced lightweight-metal supplier base for the U.S. to compete in the global market; while enabling the DOD to realize significant fuel reduction, increased payloads, and greater speed and agility of manned, unmanned, and soldier systems.

Description of Activity: The focus of the LM3I Institute will be on the integrated design and manufacturing of lightweight components and structures for commercial and defense applications, and the verification of those designs through pilot production and validation through experimental testing. The LM3I Institute will work in collaboration with industry, academia, and government in four key areas:

1. Rapidly maturing and demonstrating production scale-up of existing, innovative, lightweight alloys;

2. Shortening the time necessary to design and integrate novel, affordable, metals, including lightweight alloys and third generation steels into new products;
3. Develop more affordable, competitive, automated manufacturing processes; and
4. Develop the tools, skills and knowledge base within the materials design and manufacturing workforce to use an Integrated Computational Materials Engineering (ICME) infrastructure efficiently and effectively.

The long-term goals are to create market expansion and new consumers of lightweight products, along with partnerships with automotive, aerospace, energy, defense and recreational equipment industries that enable maturation and scale-up of modern metals to maintain global cost competitiveness for U.S. industries, and technological leadership for National Security. To that end, all technological approaches must envisage a credible path to market. The DoD is interested in concepts that would enable partnerships to develop new products and processes matured to MRL 4-7 that can impact commercial production.

Technical/Scale-Up Challenges: Current market demands for lightweight materials are being met with available alloys; however, a national institute can significantly affect the price and availability of popular (widely used) and “boutique” materials by scaling-up existing and alternative production methods as well as issuing guidelines for testing, qualifying and certifying materials for both defense and commercial applications. This includes capital equipment, and in some cases facilities, necessary to manufacture and scale the processes to production levels. The scale-up of manufacturing technologies for promising, lightweight materials often requires levels of risk that exceed industry thresholds yet can be effectively addressed through a public-private partnership embodied by the LM3I institute.

Illustrative Examples: (Potential outcomes)

DoD: The Joint Light Tactical Vehicle (JLTV) is a good example of a DoD system that can benefit from the work of this Institute. JLTV is a family of more survivable, higher payload vehicles that are planned to succeed the High Mobility, Multi-Wheeled Vehicle (HMMWV or Humvee). One variant of the JLTV has been eliminated because it was too heavy to meet the weight requirement of being transportable by Army and Marine Corps helicopters. The manufacturing technologies coming out of the LM3I Institute that can assist the JLTV program to include lighter weight materials that meet the ballistic, multi-threat requirements for under body protection (similar to the Mine-Resistant, Ambush-Protected All-Terrain Vehicle [M-ATV]), body armor panels, and Gunner Protection Kits (GPKs) on top of the vehicles. In addition, “mission-tailorable” armor materials that can be tuned and scaled for any requirement would be of great benefit as well.

Commercial: As weight reduction is a cost-effective means to reduce fuel consumption and greenhouse gases in the transportation industry, a national institute focused on scaling and testing lightweight, high strength materials to enhance payload and energy efficiency would help the U.S. meet national efficiency and environmental policy priorities. Specifically, the LM3I institute can become a go-to center for U.S. manufacturers to more cost competitively identify, test and incorporate new lightweight materials for engine, body/wing, etc. components while materials companies can greatly reduce the risk of market expansion/scale-up by employing the services/capabilities of this Institute.